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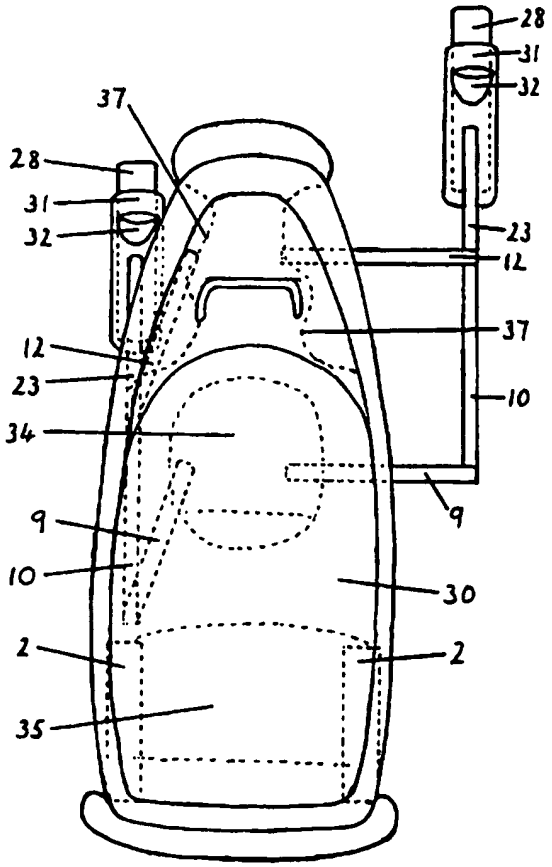
(54) Title: VARIABLE TRACK VEHICLE

(57) Abstract

A short, narrow motor vehicle has a parallelogram linkage at each side to which the front (or rear) road wheels are connected. This enables these wheels to be displaced, laterally and lengthwise, in a co-ordinated way. If the displaceable wheels are the front wheels, a steering mechanism is provided to enable the wheels to be steered irrespective of the extent of their displacement, including during actuation of the displacement mechanism. The figure shows, in plan view, steerable 13 front wheels (28) at their maximum lateral displacement. In this diagrammatic representation, control of steering is by means of handlebars (15) acting through various meshing gears, chains and sprockets; and control of the lateral and lengthwise displacement is by means of a lever (3) acting through other meshing gears and pivotally connected elements.



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Title: VARIABLE TRACK VEHICLE

Description of Invention

This invention relates to motor vehicles.

The invention has been devised with the object in view of providing a motor vehicle for transport of one or a small number of persons, which is able to occupy a minimum amount of road space whilst overcoming certain disadvantages, as pointed out hereafter, which have been associated with vehicles for such purposes as generally known hitherto.

Two-wheeled motor vehicles, i.e. motorcycles, are highly manoeuvrable and occupy little road space, particularly in respect of their widths. They can be ridden through narrow gaps in traffic and require little room for parking. However, they require a high level of riding skill if they are to be ridden safely, require to be supported by the rider's legs or by stabilising devices when stationary or travelling extremely slowly, cannot be ridden in reverse, and can become uncontrollable if even one of the wheels should lose grip with the road surface. For safety reasons and for protection from the weather, the rider should wear protective clothing which is inconvenient and time consuming to put on and take off. Fully enclosed motorcycles have been proposed but are large, heavy, and require special measures to overcome the stability problem.

Conventional four-wheel vehicles, i.e. motor cars, overcome the safety and weather protection disadvantages of motorcycles but, because of their width, cannot be driven through narrow gaps in heavy traffic and require considerable space for parking. Most cars are unnecessarily large, heavy and fuel consuming for journeys which involve carrying only one or two persons.

There have been three-wheeled cars but, if they are to be stable when cornering, they require dimensions particularly in respect of their width which are comparable with, or even greater than, those of four-wheeled cars and therefore offer no advantage in respect of the road space they occupy.

There have been proposals for vehicles with three or more wheels which are much narrower than conventional motor cars. For stability, arrangements have been proposed which enable a part of the vehicle to tilt laterally when cornering, so that the centre of gravity of the vehicle is displaced relative to the positions at which the wheels of the vehicle contact the ground. Such tilting, in the manner of the leaning of a motorcycle when cornering, towards the centre of the turning circle of the vehicle, enables a comparatively narrow vehicle to corner in safety at a much higher speed than would otherwise be possible. One example of such a vehicle is disclosed in EP-0020835-B, of Jephcott but a disadvantage of it is the necessity of providing a powered tilting mechanism. Another such vehicle was disclosed in UK-9408066.0, of Gee (but not pursued). This avoids the need for a powered tilting mechanism but depends on the strength and skill of the rider, thereby reducing its advantage as compared with a motorcycle.

An alternative approach to the problem of stability when cornering, at more than a very low speed, is to provide a mechanism for increasing the track dimension of either, or both, front or rear wheels. Some agricultural tractors or mechanical handling vehicles have adjustable track widths but of a kind that can only be adjusted when they are stationary. In order to combine the advantages of compactness when stationary or travelling very slowly with stability at higher speeds, a mechanism is required to vary track width whilst the vehicle is in motion. Moreover, as a very compact four-wheeled vehicle would have too short a wheelbase for satisfactory stability and comfort when travelling at higher speeds on uneven surfaces, it is also desirable to provide a means for lengthening the wheelbase at higher speeds. The mechanism or mechanisms to provide these adjustments must be simple to operate and reliable in use. The driver should also be able to see the configuration of the relevant wheels at any time.

With these desiderata in view, according to one aspect of the present invention, I provide a motor vehicle comprising:

a chassis structure (but not necessarily a separate chassis frame), which may be integral with the body structure specified hereafter, suspension means including at least three ground-engaging wheels (hereinafter referred to as road wheels and of which at least two form a lateral pair) mounted to the chassis structure, means for mounting a prime mover and associated transmission on the chassis structure for the purpose of transmitting drive to

at least one of the road wheels, a body structure for at least one user of the vehicle mounted on, or integral with, the chassis structure;

said chassis structure providing user actuable means for enabling lateral and lengthwise displacement of at least one (or, if the vehicle has only three road wheels, the only lateral) pair of road wheels, in co-ordination with each other, with respect to the other wheel(s) and the chassis structure, including means whereby the lateral and lengthwise displacement of the displaceable road wheels is controlled by elements pivotally connected together generally in parallelogram configuration (as viewed in plan), each wheel provided with lengthwise and lateral movement being connected, with appropriate suspension, to the outer longitudinal element of the appropriate parallelogram, and means for locking the displaceable road wheels in at least one displacement configuration; the arrangement being such that the assembly of elements connected together in parallelogram configuration is capable of assuming a position (herein called the retracted position) in which the lateral width of each parallelogram is at its minimum, a position (herein called the extended position) in which the lateral width of each parallelogram is at its maximum, and any geometrically possible position intermediate between the retracted and extended positions, or positions beyond the extended position in which the lengthwise displacement from the retracted position is further increased but the lateral displacement from the extended position is reduced; thereby enabling the vehicle to have a narrow track and short wheelbase or a wider track and longer (but less than maximum) wheelbase or a track between the minimum and maximum width in conjunction with a wheelbase which is longer than when the track is at its maximum width;

said chassis structure providing means for steering at least one lateral pair of road wheels in co-ordination with one another and in co-ordination with the lengthwise and lateral movement, if applicable to said lateral pair of wheels, irrespective of the extent of lateral and lengthwise displacement and including means for steering such pair of road wheels while lateral and lengthwise displacement is being effected, the mechanism being such that the steering ratio is substantially independent of the lengthwise and lateral displacement of the wheels.

Preferably the vehicle is a four-wheeled vehicle, with a pair of front wheels and a pair of rear wheels.

Preferably the mechanism providing lengthwise and lateral movement applies to the front wheels and, if so, preferably these wheels are not driven. Such mechanism may also apply to the rear wheels which may also be driven by means of an electric or hydraulic motor at each wheel or such other means as may be devised.

Preferably, a mechanism, which may comprise meshing gears, sprockets and chains, further pivotally connected elements, or some combination of these, which ensures that the amount of lateral and lengthwise movement of each wheel, being one of a lateral pair, is substantially the same.

Preferably, a speed-sensitive mechanism for locking the parallelogram linkages in the extended position so that the linkages cannot be retracted inadvertently (whether by the driver or by unequal cornering or braking forces on the two wheels concerned) while the vehicle is travelling a speed above that at which retraction would be safe.

Preferably, if lengthwise and lateral movement applies to the front wheels, the chassis structure of the vehicle includes a steering mechanism such that the steering ratio is substantially independent of whether the front wheels are in the retracted position, extended position or any intermediate position or any position beyond the extended position. Such steering mechanism may comprise meshing gears, sprockets and chains, further pivotally connected elements, or some combination of these.

It is to be understood that when I refer to the chassis structure comprising elements in parallelogram configuration, in practice the arrangement may differ from a true parallelogram. This allows the designer to provide different degrees of toe-in or toe-out in the retracted and extended positions, if desired. Similarly, the steering mechanism may allow some small variation in steering ratio between the retracted and extended positions in order to allow the Ackermann angle to vary, if desired.

Steering of the vehicle may be by means of a handle bar or steering wheel disposed within the body structure of the vehicle so as able to be held by the driver.

Control of lengthwise and lateral movement of the relevant elements of the chassis may be effected by various means: for example, of a foot-operated lever such that when the driver pushes with his or her right foot the mechanism extends and when he or she pushes with the left foot it retracts. It is envisaged that this mechanism will be activated

when the vehicle is travelling at about 15kph: at such speed the driver should be able to exert the force needed to induce about 1 cm of lateral movement of the tyres relative to the road surface for each revolution of the road wheels. Nevertheless, electrical or hydraulic power assistance may be provided which would also have the advantage that the control could be a relatively small switch or lever which may be operated by the driver's fingers without removing his or her hand entirely from the handle bar or steering wheel. It would be within the scope of the invention if the vehicle were to be provided with powered, automatic operation to extend the mechanism as the vehicle speed rises above a pre-set level and to retract it as the vehicle speed falls below such level, although some manual over-ride would still be desirable to prevent extension or retraction in certain road or traffic conditions.

The invention will now be described by way of example with reference to the accompanying drawings, of which:-

Figure 1 is a diagrammatic plan view showing the main elements of the chassis structure and arrangement of movable elements of a vehicle according to the present invention, in the "extended" condition;

Figure 2 is a view as Figure 1, in the "retracted" condition;

Figure 3 is a diagrammatic side view of the same elements of the vehicle as are shown in Figures 1 and 2, in the "extended" condition;

Figure 4 is a diagrammatic side view of the same elements of the vehicle as are shown in Figures 1 and 2, in the "retracted" condition;

Figure 5 is a diagrammatic front view of the same elements of the vehicle as are shown in Figures 1 and 2, in the "extended" condition (but omitting members 3 to 8 inclusive);

Figure 4 is a diagrammatic front view of the same elements of the vehicle as are shown in Figures 1 and 2, in the "retracted" condition (but omitting members 3 to 8 inclusive);

Figure 7 is a side view of a vehicle, according to the invention, in the "extended" condition, including (shown dotted) certain components not visible from outside the vehicle;

Figure 8 is a side view of the vehicle shown in Figure 7, in the "retracted" condition;

Figure 9 is a plan view of the vehicle shown in Figure 7: for convenience in showing the two extreme conditions, the left side is shown "retracted" and the right "extended" (even though such a combination would not exist in practice); and certain components not visible from outside the vehicle are shown dotted.

Referring firstly to Figures 1 to 6 of the drawings, these show diagrammatically a possible arrangement of components constituting the chassis structure of a vehicle according to the invention. Some components are shown as straight lines oriented and connected to one another as described hereafter, but it is to be appreciated that in a real vehicle such components will be constructed and arranged generally in accordance with current or future automotive practice. The vehicle shown incorporates lengthwise and lateral movement and the associated steering mechanism as for the front wheels of a vehicle according to the invention. If the rear wheels are also required to move laterally and lengthwise, a mirror image of components 11 to 14, about the axis formed by components 8, would be linked to the rear wheels 2: it would be connected to lever 3 by a similar combination of gear wheels to components 5 to 7 but arranged so that gear wheels corresponding to wheels 7 rotate in the opposite direction causing the rear wheels 2 move rearwards as they move outwards. The words "vertical" and "horizontal", as used in the following description, are to be understood to include such approximations to these orientations as may occur when the vehicle is in motion .

The chassis structure of the vehicle comprises, firstly, a rigid platform 1 which is generally of rectangular configuration in plan view. In practice, as above referred to in accordance with current or future automotive practice, the platform 1 would probably be constructed as a one (or more)-piece metal pressing or fabrication, or moulded component of fibre-reinforced plastics, carbon fibre or other suitable material, and possibly integral with the vehicle body. At the rear end of the platform 1, having regard to the normal direction of travel of the vehicle in use, there is a pair of rear wheels 2 with appropriate drive mechanism and suspension (not shown). Towards the middle of the platform 1, a hand- or foot-operated lever 3 is rigidly connected to a vertical shaft 4 which passes through a bearing in the platform 1 to a toothed gear wheel 5 which is rigidly connected to the shaft 4. In practice, shaft 4 might be turned by an electric motor or hydraulic pressure, or a further mechanism could be arranged to bring a lever to a convenient position for the driver. The gear wheel 5 is in constant mesh with an idler gear wheel 6, rigidly connected to a vertical

shaft supported by a bearing in platform 1. The gear wheel 6 is in constant mesh with a further gear wheel 7 rigidly connected to a vertical shaft 8 near the right side of the platform 1 (as seen by a driver facing forwards) and supported by a bearing in the platform 1. An identical gear wheel 7, rigidly connected to a vertical shaft 8 near the left side of platform 1, is in constant mesh with the gear wheel 5. For clarity, some components are shown in Figures 1 and 2 as if they were above the platform 1 although, in Figures 3 to 6, they are shown below platform 1. A rigid horizontal member 9 is rigidly connected to each wheel 7. A rigid member 10 is pivotally connected to each member 9 at joints 11. Each member 10 is pivotally connected to a rigid horizontal member 12 by means of a vertical shaft 13 around which members 10 and 12 may turn. The other end of each member 12 is pivotally connected to a vertical shaft 14 supported by a bearing in the platform 1. The bearings supporting the shafts 8, 13 and 14 and the joints 11 allow movement between the members 1, 9, 10 and 12 in the horizontally-oriented plane in which the members 1, 9, 10 and 12 lie, but in no other direction. Thus, at each side of the vehicle, the platform 1 and members 9, 10 and 12 comprise a parallelogram linkage such that, as lever 3 is moved in an anti-clockwise direction (as seen from above), the members 10 move laterally away from the platform 1 and forward relative to the platform 1. In practice, at each side of the vehicle, the bearings supporting the shafts 8, 13 and 14, the members 9, 10 and 12 and the joint 11 may be duplicated to form a second parallelogram linkage operating in a different horizontal plane (directly above or below that shown) in order to counteract the bending moments in the linkage when the mechanism is in the extended position.

At the front of the vehicle, handlebars (or a steering wheel) 15 are rigidly attached to a vertical shaft 16 supported by a bearing in platform 1. In practice, the shaft 16 may incorporate a universal joint so that the part of the shaft below the joint is vertical but the part above the joint is supported by a bearing in a position arranged to enable the handlebars (or steering wheel) 15 to be aligned conveniently for the driver. A gear wheel 17 is rigidly connected to shaft 16. The gear wheel 17 is in constant mesh with an idler gear wheel 18 which is rigidly connected to a vertical shaft supported by a bearing in platform 1. The relative radii of the gear wheels 17 and 18 will be chosen to provide the desired steering ratio. Further gear wheels 19 are rigidly attached to the shafts 14 and are both in constant mesh with the gear wheel 18. Sprocket wheels 20 are rigidly connected to the shafts 14. Further sprocket wheels 21 are rigidly connected to the shafts 13. At each side of the vehicle,

sprocket wheel 20 is connected to sprocket wheel 21 by means of a chain 22. At each side of the vehicle, a member 23 is rigidly connected to member 10 so as to provide a forward extension of member 10 but in a higher horizontal plane. Each member 23, and the corresponding member 10, form a rigid structure in a vertically-oriented plane. Further sprocket wheels 24 are rigidly attached to the shafts 13. At each side of the vehicle, a vertical shaft 25 is supported by a bearing near the front of member 23. Sprocket wheels 26 are rigidly connected to the shafts 25. At each side of the vehicle, sprocket wheel 24 is connected to sprocket wheel 26 by means of a chain 27. Front road wheels 28 are connected, with suitable suspension (not shown), to the shafts 25 in such a way that they turn about the axes of shafts 25 as shafts 25 turn: the suspension and connections may be as normally found in the front forks of a motor cycle but other arrangements are possible. The effect of the arrangement of members 16 to 27 inclusive is that, when the handlebars (or steering wheel) 16 are turned, the road wheels 28 turn in the same direction and with a steering ratio that remains substantially constant irrespective of whether the parallelograms formed by members 1, 9, 10 and 12 are in the extended or retracted position or any intermediate position.

Referring to figures 7 and 8, the sprocket wheels 21, 24 and 25 and the chains 27 are (mainly) enclosed within housings 29.

Referring to figures 7, 8 and 9, the main external panels and windows of a saloon-type vehicle body 30 are shown. Cycle-type mudguards 31 and driving lamps 32 are connected to the supports for the front wheels 28. The engine and gearbox are covered by a cover 33. A seat 34 for the driver and a second seat 35, which could be for one adult or two children, are provided. A door 36 is provided on one side of the vehicle: there is no similar door on the other side where exit through the window would be possible in an emergency. When in the retracted condition, the front wheels 28 may be steered within the limits of the inner wheel arches 37.

From Figure 9 it will be appreciated that, in the "retracted" condition, the vehicle is of relatively narrow width and length compared with conventional cars, and thus occupies a minimum of road space.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result,

as appropriate, may, separately or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

Claims

1. A motor vehicle comprising:

a chassis structure (but not necessarily a separate chassis frame), which may be integral with the body structure specified hereafter, suspension means including at least three ground-engaging wheels (hereinafter referred to as road wheels and of which at least two form a lateral pair) mounted to the chassis structure, means for mounting a prime mover and associated transmission on the chassis structure for the purpose of transmitting drive to at least one of the road wheels, a body structure for at least one user of the vehicle mounted on, or integral with, the chassis structure;

said chassis structure providing user actuable means for enabling lateral and lengthwise displacement of at least one (or, if the vehicle has only three road wheels, the only lateral) pair of road wheels, in co-ordination with each other, with respect to the other wheel(s) and the chassis structure, including means whereby the lateral and lengthwise displacement of the displaceable road wheels is controlled by elements pivotally connected together generally in parallelogram configuration (as viewed in plan), each wheel provided with lengthwise and lateral movement being connected, with appropriate suspension, to the outer longitudinal element of the appropriate parallelogram, and means for locking the displaceable road wheels in at least one displacement configuration; the arrangement being such that the assembly of elements connected together in parallelogram configuration is capable of assuming a position (herein called the retracted position) in which the lateral width of each parallelogram is at its minimum, a position (herein called the extended position) in which the lateral width of each parallelogram is at its maximum, and any geometrically possible position intermediate between the retracted and extended positions, or positions beyond the extended position in which the lengthwise displacement from the retracted position is further increased but the lateral displacement from the extended position is reduced; thereby enabling the vehicle to have a narrow track and short wheelbase or a wider track and longer (but less than maximum) wheelbase or a track between the minimum and maximum width in conjunction with a wheelbase which is longer than when the track is at its maximum width;

said chassis structure providing means for steering at least one lateral pair of road wheels in co-ordination with one another and in co-ordination with the

lengthwise and lateral movement, if applicable to said lateral pair of wheels, irrespective of the extent of lateral and lengthwise displacement and including means for steering such pair of road wheels while lateral and lengthwise displacement is being effected, the mechanism being such that the steering ratio is substantially independent of the lengthwise and lateral displacement of the wheels.

2. A motor vehicle as claimed in Claim 1, wherein the angle at one of the vertices of each parallelogram is controlled by intermeshing gears, one of which is provided with a means of user actuation.

3. A motor vehicle as claimed in Claim 1, wherein the angle at one of the vertices of each parallelogram is controlled by a combination of intermeshing gears, or sprocket wheels and chains, or further pivotally connected elements, one of which is provided with a means of user actuation.

4. A motor vehicle as claimed in Claim 1, wherein the user actuated steering control is connected to the displaceable road wheels by intermeshing gears, or sprocket wheels and chains, or further pivotally connected elements, or some combination of such elements.

5. A motor vehicle as claimed in Claim 1, wherein means are provided for preventing actuation of the displacement mechanism while the vehicle is travelling at more than a pre-determined speed.

6. A motor vehicle as claimed in Claim 1 or Claim 5, wherein means are provided for automatic actuation to increase the displacement of the displaceable wheels when the vehicle speed increases above a pre-determined level and to reduce the displacement when the vehicle speed decreases below a pre-determined level.

7. A motor vehicle as claimed in Claim 6, wherein means are provided to enable the user to over-ride the automatic actuation of the displacement of the displaceable road wheels.

8. A motor vehicle as claimed in Claims 1, 2, 3, 4, 5, 6 or 7, wherein the means for effecting the road wheel displacement include a power- operated or power-assisted mechanism actuated by the user.

9. A motor vehicle as claimed in Claim 1, 2, 3, 4, 5, 6, 7 or 8 in which at least one (or, if the vehicle has only three road wheels, the only lateral) pair of road wheels is visible to the user irrespective of the extent of displacement.

10. A motor vehicle substantially as described herein with reference to Figures 1-9 of the accompanying drawings.

AMENDED CLAIMS

[received by the International Bureau on 16 February 1999 (16.02.99);
original claim 1 amended;
remaining claims unchanged (3 pages)]

1. A motor vehicle comprising:

a chassis structure (but not necessarily a separate chassis frame), which may be integral with the body structure specified hereafter, suspension means including at least three ground-engaging wheels (hereinafter referred to as road wheels and of which at least two form a lateral pair) mounted to the chassis structure with appropriate suspension and brakes, means for mounting a prime mover and associated transmission on the chassis structure for the purpose of transmitting drive to at least one of the road wheels, a body structure for at least one user of the vehicle mounted on, or integral with, the chassis structure;

said chassis structure providing user actuable means for enabling lateral and lengthwise displacement of at least one (or, if the vehicle has only three road wheels, the only lateral) pair of road wheels, in co-ordination with each other, with respect to the other wheel(s) and the chassis structure, including means whereby the lateral and lengthwise displacement of the displaceable road wheels is controlled by elements pivotally connected together generally in parallelogram configuration (as viewed in plan), each wheel provided with lengthwise and lateral movement being connected, with appropriate suspension, to the outer longitudinal element of the appropriate parallelogram, and means for locking the displaceable road wheels in at least one displacement configuration; the arrangement being such that the assembly of elements connected together in parallelogram configuration is capable of assuming a position (herein called the retracted position) in which the lateral width of each parallelogram is at its minimum, a position (herein called the extended position) in which the lateral width of each parallelogram is at its maximum, and any geometrically possible position intermediate between the retracted and extended positions, or positions beyond the extended position in which the lengthwise displacement from the retracted position is further increased but the lateral displacement from the extended position is reduced; thereby enabling the vehicle to have a narrow track and short wheelbase or a wider track and longer (but less than maximum) wheelbase or a track between the minimum and maximum width in conjunction with a wheelbase which is longer than when the track is at its maximum width;

said chassis structure providing means for steering at least one lateral pair of road wheels in co-ordination with one another and in co-ordination with the lengthwise and lateral movement, if applicable to said lateral pair of wheels, irrespective of the extent of lateral and lengthwise displacement and including means for steering such pair of road wheels while lateral and lengthwise displacement is being effected, the mechanism being such that the steering ratio is substantially independent of the lengthwise and lateral displacement of the wheels.

2. A motor vehicle as claimed in Claim 1, wherein the angle at one of the vertices of each parallelogram is controlled by intermeshing gears, one of which is provided with a means of user actuation.

3. A motor vehicle as claimed in Claim 1, wherein the angle at one of the vertices of each parallelogram is controlled by a combination of intermeshing gears, or sprocket wheels and chains, or further pivotally connected elements, one of which is provided with a means of user actuation.

4. A motor vehicle as claimed in Claim 1, wherein the user actuated steering control is connected to the displaceable road wheels by intermeshing gears, or sprocket wheels and chains, or further pivotally connected elements, or some combination of such elements.

5. A motor vehicle as claimed in Claim 1, wherein means are provided for preventing actuation of the displacement mechanism while the vehicle is travelling at more than a pre-determined speed.

6. A motor vehicle as claimed in Claim 1 or Claim 5, wherein means are provided for automatic actuation to increase the displacement of the displaceable wheels when the vehicle speed increases above a pre-determined level and to reduce the displacement when the vehicle speed decreases below a pre-determined level.

7. A motor vehicle as claimed in Claim 6, wherein means are provided to enable the user to over-ride the automatic actuation of the displacement of the displaceable road wheels.

8. A motor vehicle as claimed in Claims 1, 2, 3, 4, 5, 6 or 7, wherein the means for effecting the road wheel displacement include a power- operated or power-assisted mechanism actuated by the user.

9. A motor vehicle as claimed in Claim 1, 2, 3, 4, 5, 6, 7 or 8 in which at least one (or, if the vehicle has only three road wheels, the only lateral) pair of road wheels is visible to the user irrespective of the extent of displacement.

10. A motor vehicle substantially as described herein with reference to Figures 1-9 of the accompanying drawings.

STATEMENT UNDER ARTICLE 19

Claim 1 of the application is amended to make it clearer that the proposed vehicle would be equipped with suspension and brakes for each of the road wheels, thereby distinguishing it from vehicles intended primarily for agricultural or horticultural purposes.

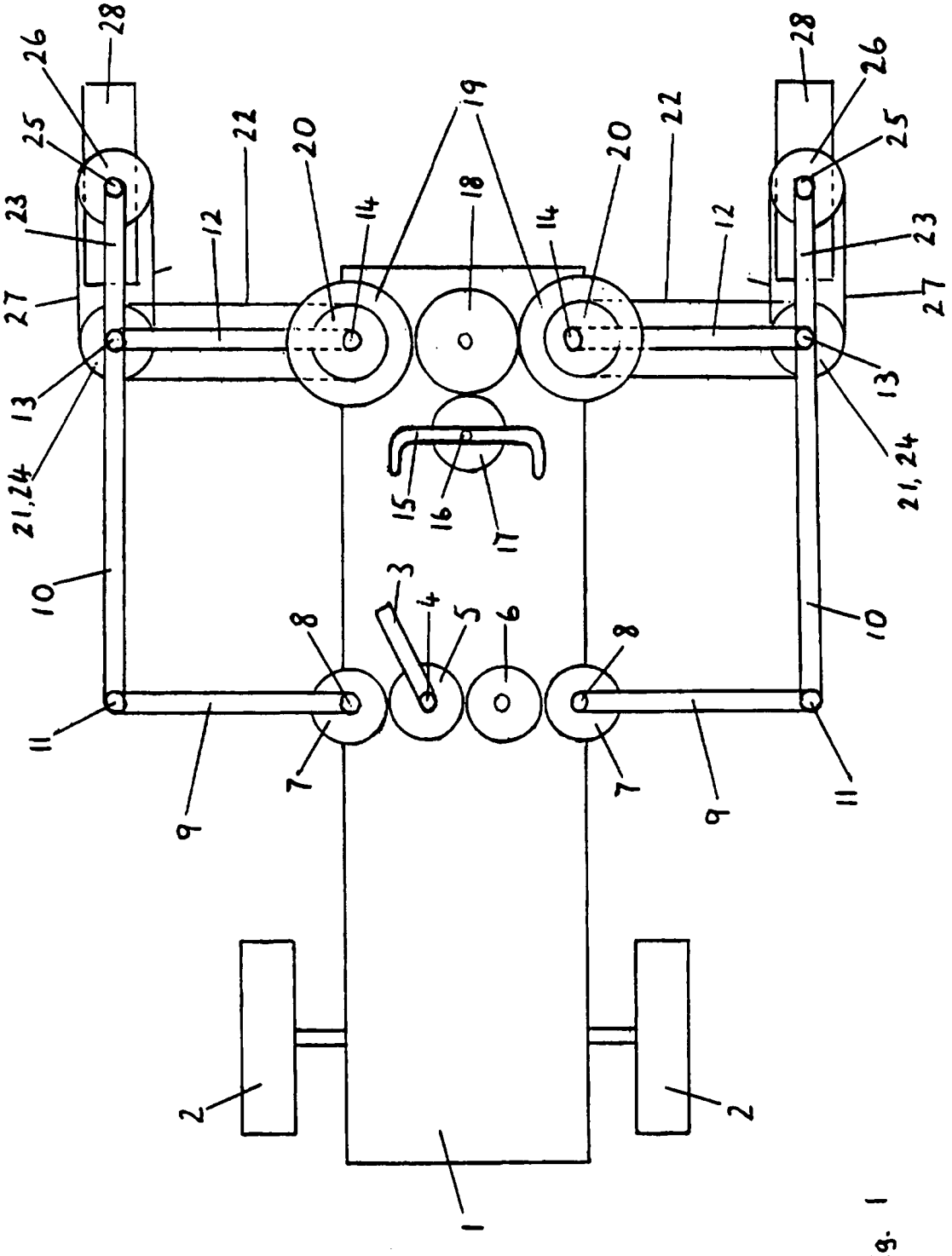

Fig. 1

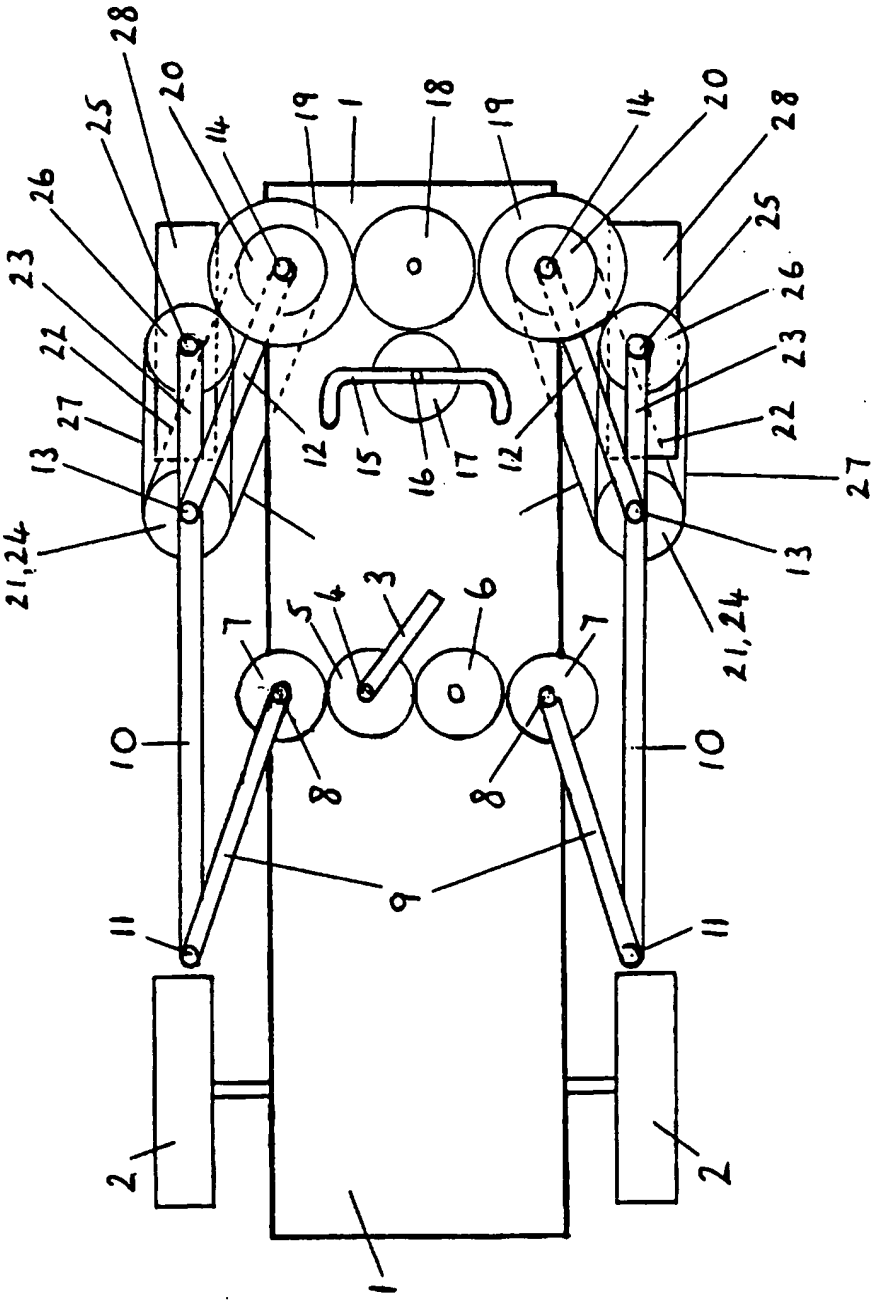
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Fig. 2

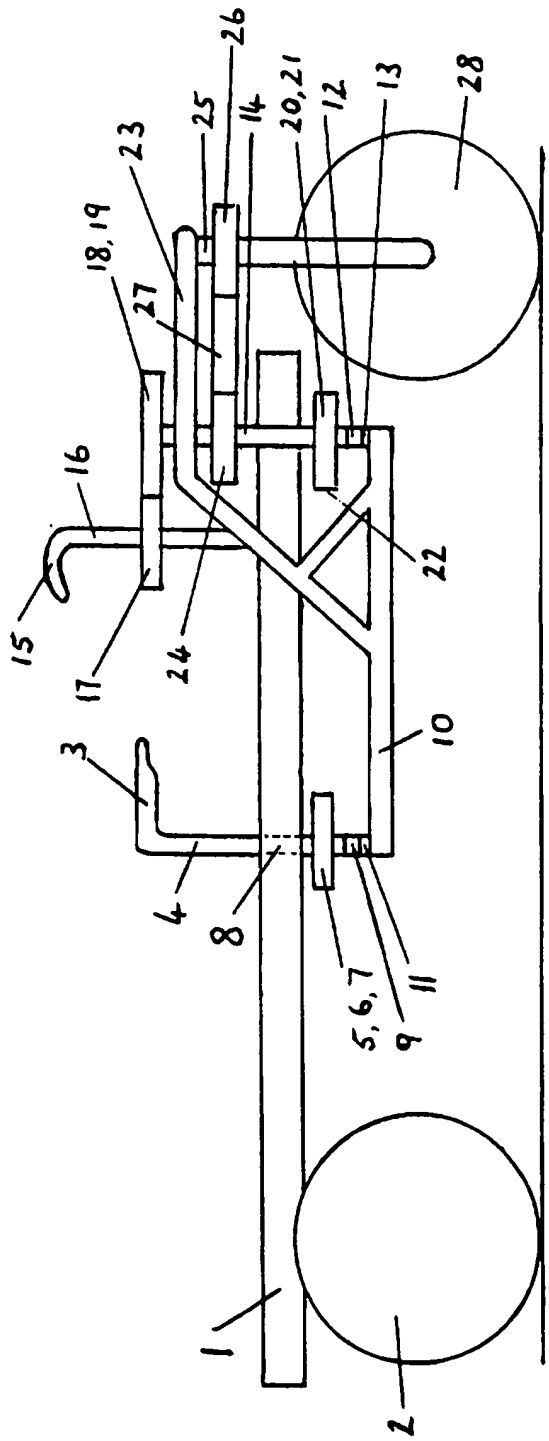
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Fig. 3

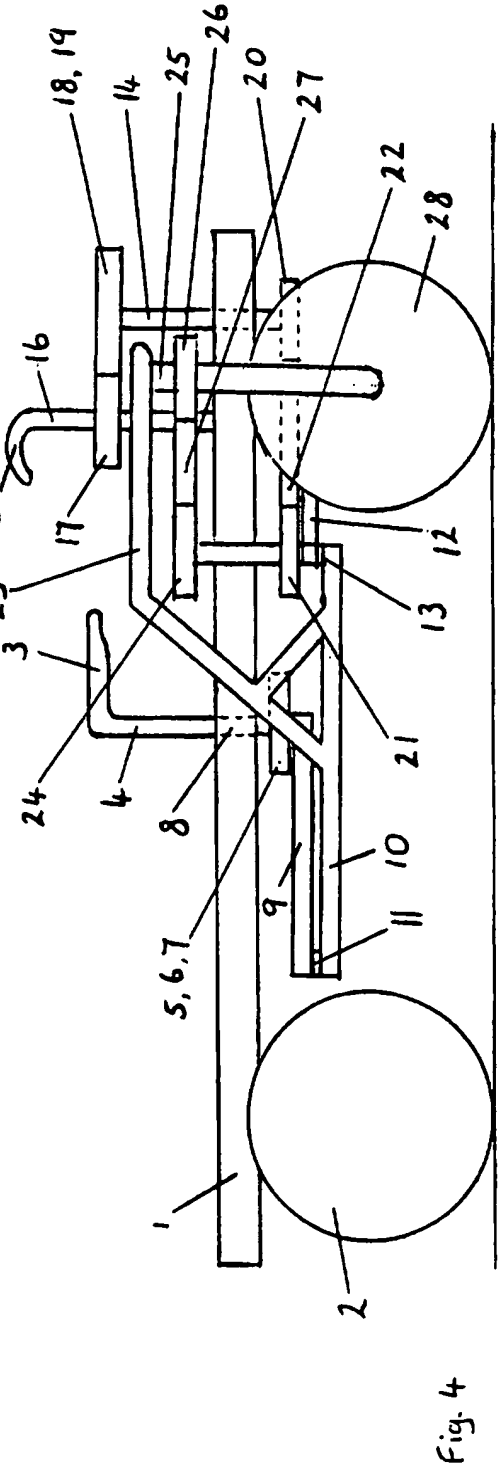
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Fig. 4

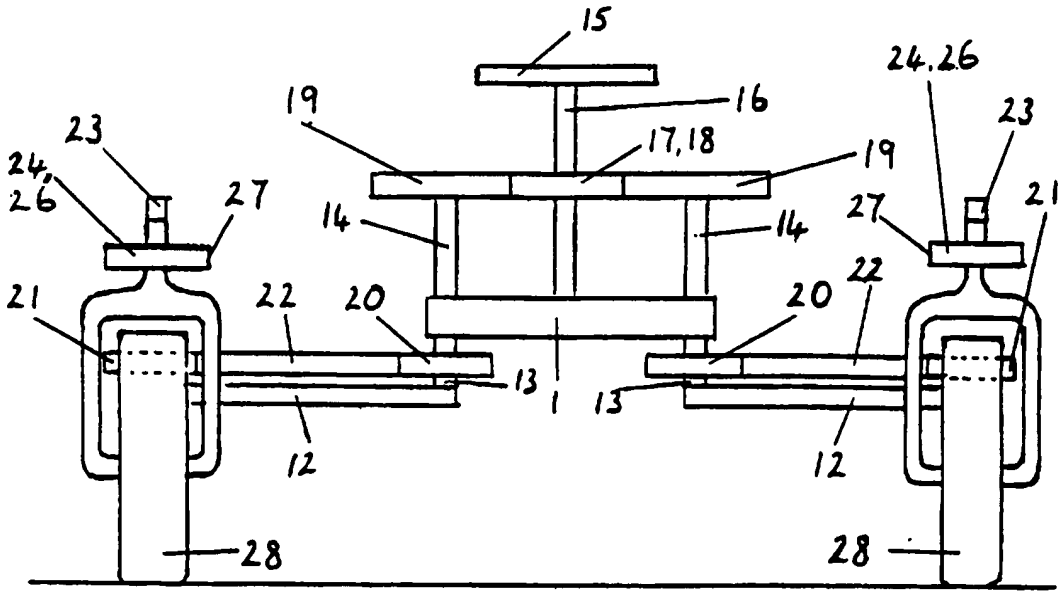
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Fig. 5

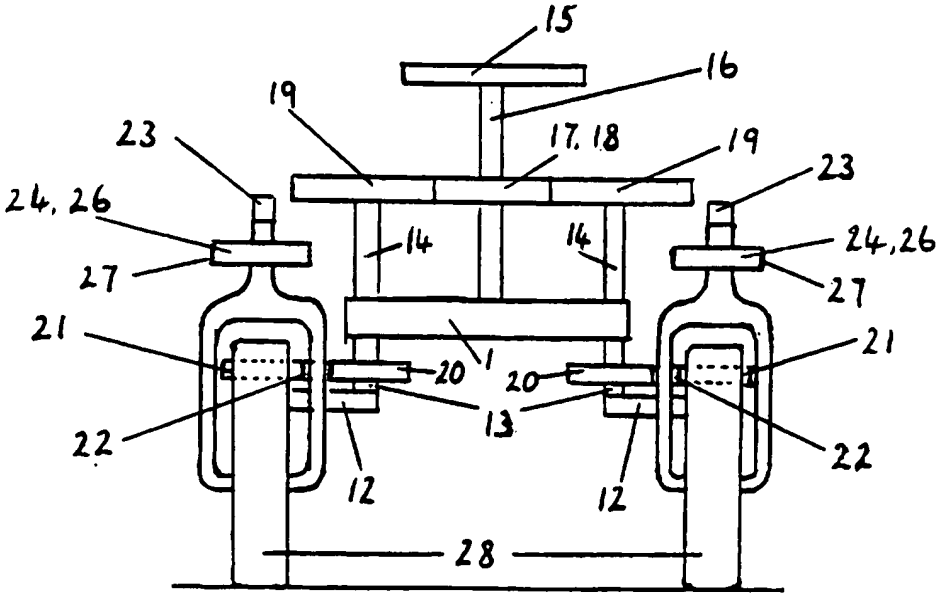
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Fig. 6

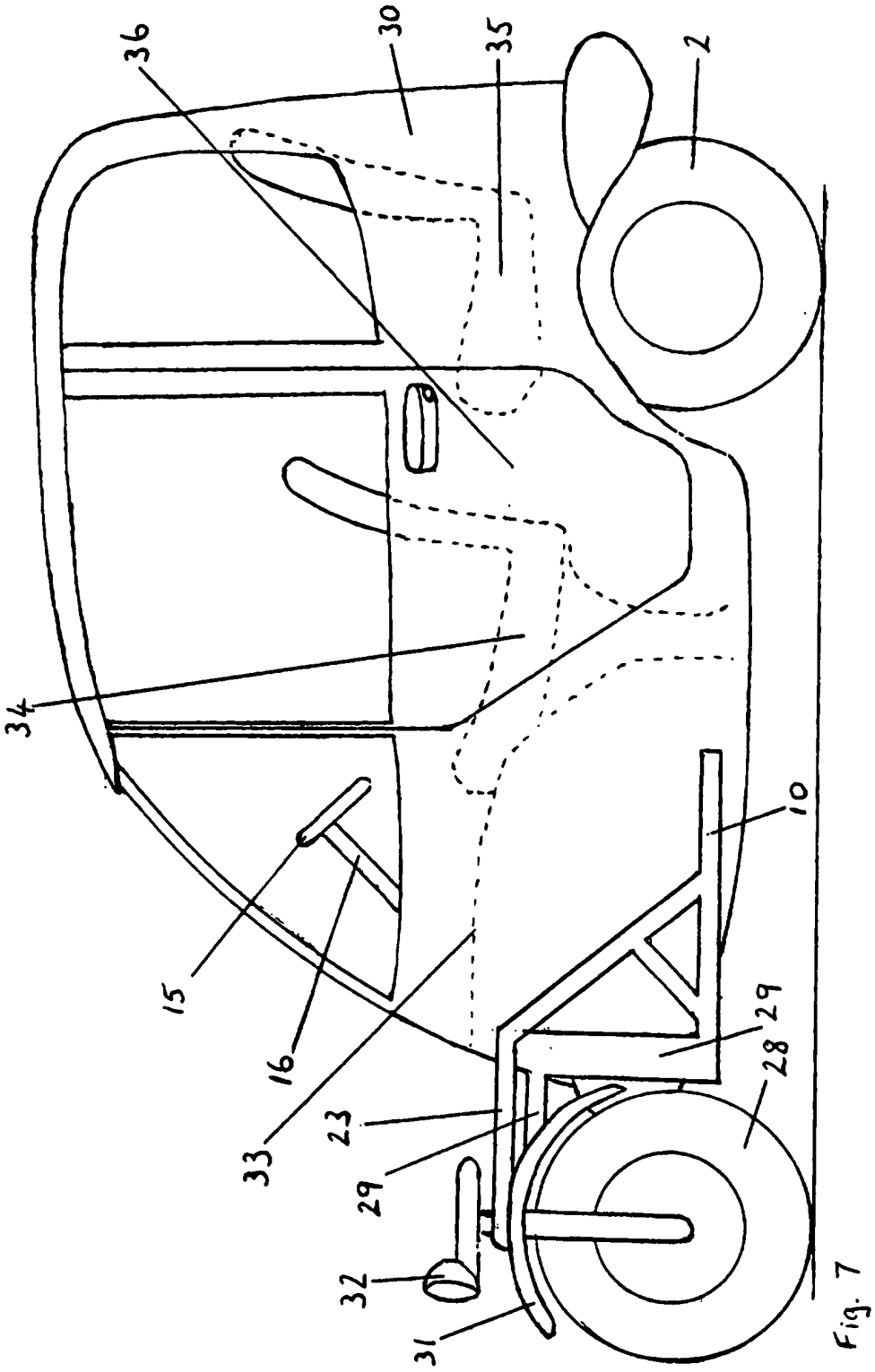

Fig. 7

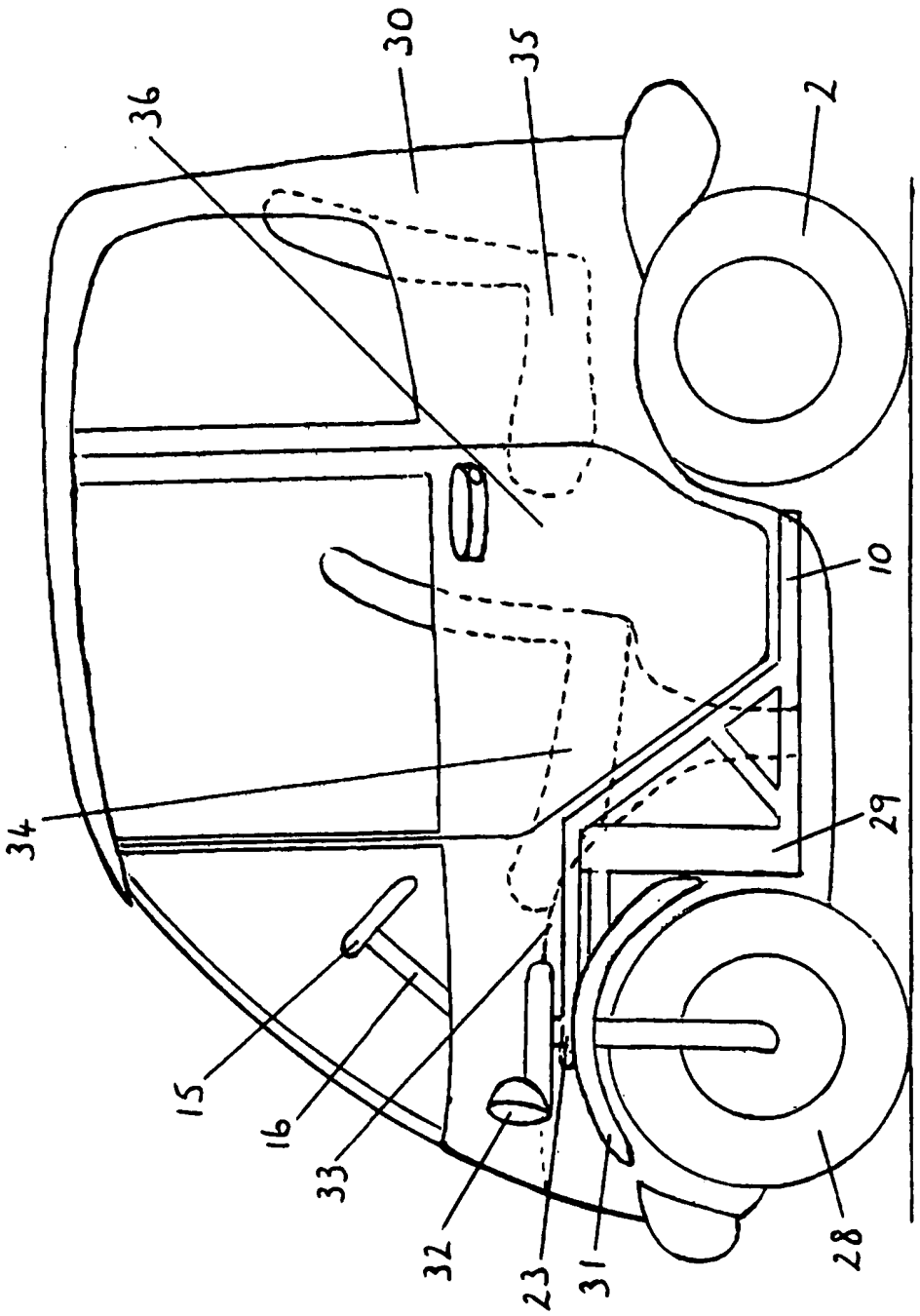

Fig. 8

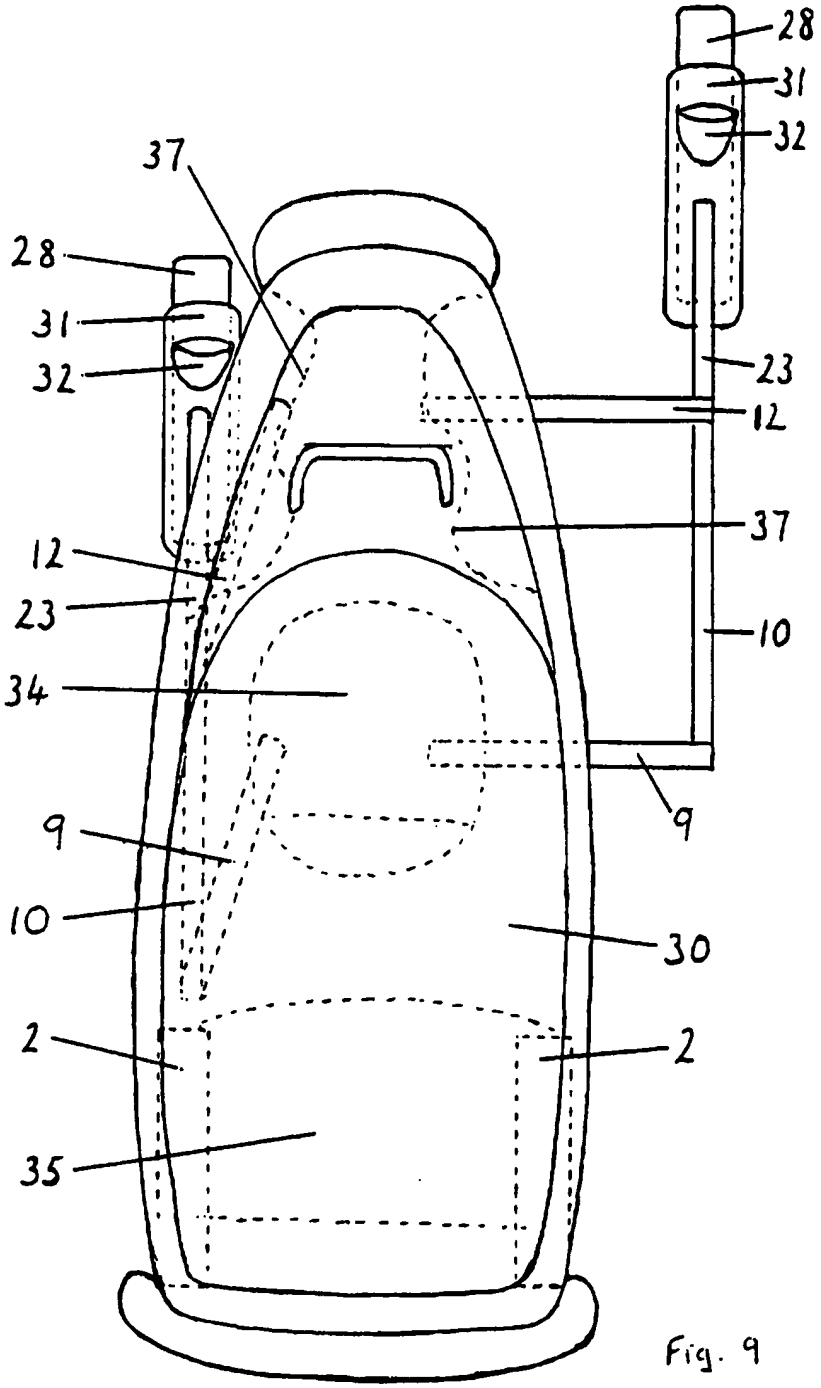

Fig. 9

INTERNATIONAL SEARCH REPORT

Inter. Application No
PCT/GB 98/00947

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B62D31/00 B60B35/10 B62D49/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B62D B60B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 61 226301 A (KUBOTA LTD) 8 October 1986 see figures	1,3,4,8,9
X	DE 907 838 C (LANZ) 29 March 1954 see page 2, line 107 - line 118; figure 3	1,3,4
E	GB 2 317 862 A (GEE DAVID HOWARD) 8 April 1998 see the whole document	1-10
A	WO 89 03336 A (BURKE INC) 20 April 1989 see page 7, line 23 - page 8, line 34; figure 3 see page 10, line 26 - line 35 see page 2, line 12 - page 3, line 9	1,8,9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
14 December 1998	21/12/1998

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Inter. ...nal Application No
PCT/GB 98/00947

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	FR 1 442 426 A (RIGNAULT) 25 August 1966 see page 1, right-hand column, last paragraph - page 2, left-hand column, paragraph 2; figures 1,2	1,5
A	US 5 697 464 A (GOJAK ALBERT IVAN) 16 December 1997 see abstract; figures	1,5
A	DE 20 18 070 A (JOST) 30 March 1972 see page 15, line 14 - line 15; figures 1,2	1,4
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WO 8903336 A	20-04-1989	US 4834409 A	30-05-1989
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